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The Canadian Productivity Review

Relative Multifactor Productivity Levels in Canada and the United States: A Sectoral Analysis

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Micro-economic Analysis Division

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Abstract

This paper has three main objectives. First, it examines the level of multifactor productivity (MFP) in Canada relative to that of the United States for the 1994-to-2003 period. Second, it examines the relative importance of differences in capital intensity and MFP in accounting for the labour productivity differences between the two countries. Third, it traces the overall MFP difference between Canada and the United States to its industry origins and estimates the contributions of the goods, services and engineering sectors to the overall MFP gap.

Our main findings are as follows. First, the overall capital intensity is as high in Canada as in the United States; but there are considerable differences in Canada's capital intensity across asset classes. Canada has considerably less machinery and equipment, about the same amount of buildings and considerably more engineering construction. Second, most of the differences in labour productivity between Canada and the United States are due to the differences in MFP. Third, our industry results show that the levels of labour productivity and MFP in the goods and the engineering sectors are closer to those of the United States. But, the level of labour and multifactor productivity in the services sector is much lower in Canada. The lower levels of labour productivity and MFP in the Canadian services sector account for most of the overall productivity level difference between the two countries.

Keywords: productivity, capital intensity, Canada–United States comparison

Executive summary

This paper examines the level of multifactor productivity (MFP) in Canada relative to that of the United States, using data that are especially constructed for this purpose to provide somewhat more comparability than has existed in the past.

A previous paper (Baldwin et al. 2005) explored the problems that needed to be resolved in order to produce estimates of the level of Canada's labour productivity relative to that of the United States. Existing estimates of the gap in the level of labour productivity were so diverse that an effort was made to provide standardized data that could be used to better estimate the level of labour productivity between Canada and the United States. The same problem exists with regard to different estimates of the level of MFP in Canada compared with that of the United States.

The relative labour productivity level measures the relative efficiency with which the two economies transform labour into output. The relative MFP level compares the relative output differences across two countries, not just to labour input differences but also to capital input differences, and it thus provides a more 'complete' measure of overall efficiency. The relative MFP level captures the difference in the overall efficiency of an economy that arises from the use of superior production techniques, technology, firm organization, firm scale and labour quality.

In addition to providing an estimate of the relative level of Canada–United States MFP, the paper also relates the estimates of relative MFP to the estimates of relative labour productivity. The differences in labour productivity between the two countries can be decomposed into two components: a component that comes from differences in the amount of capital per worker—capital intensity—and a component that comes from differences in MFP—overall efficiency. The decomposition allows us to examine the relative importance of differences in capital intensity and overall production efficiency in accounting for labour productivity differences between Canada and the United States.

Finally, the paper moves beyond the total economy (or the total business sector) that was examined in Baldwin et al. (2005). It examines differences in the relative Canadian-U.S. levels of productivity in different industries in order to estimate the contributions that individual industries make to the overall gap in MFP.

Several questions are posed in this section of the paper.

1. What are the data issues that have been addressed in this paper for comparing relative Canadian-U.S. levels of output, inputs and MFP?

An estimate of the relative MFP levels in Canada and the United States requires comparable data on outputs and inputs. To do so, the paper starts by choosing comparable data for labour, investment and output from the various sources that are produced by the statistical agencies in Canada and the United States. The paper then adjusts each, where required, to improve comparability and applies similar methodologies to estimate capital input, labour input and industry output from the appropriate source data. For capital stock, the paper starts with the

investment data by asset type and it then uses the same methodology—the perpetual inventory technique using similar geometric depreciation rates—to estimate capital stock in the two countries. For labour input, the paper estimates hours worked using comparable methods and comparable microdata sources in the two countries (see Baldwin et al. 2005 for details). For output, the paper constructs a measure of output for U.S. industries that is calculated at basic prices that can be compared with the measure of output for Canadian industries that is calculated at basic prices.

The other issue that needs to be addressed is the choice of a price unit that is to be used to compare Canadian and U.S. gross domestic products (GDPs), each of which are produced in their national currencies (Canadian and U.S. dollars, respectively). In order to compare outputs between Canada and the United States that are calculated in their respective dollar currencies we need price deflators to transform relative values of GDP measured in dollars to measures of relative real output. Relative price indices that are referred to as purchasing power parities (PPPs) are used for this purpose. These PPPs are calculated using final or market prices in the two countries. These market-price PPPs are then adjusted to be consistent with the basic-price concept of output used for this paper. The adjustment is based on relative product tax rates between Canada and the United States (or the ratio of GDP at market prices to GDP at basic prices) for the total business and non-business sectors.

2. What are the relative Canadian-U.S. levels of labour productivity, MFP and capital intensity in the total economy?

The aggregate level of labour productivity in Canada was about 89.8% of the U.S. level in 1999. The capital–labour ratio in Canada has been essentially the same as that in the United States since 1999. With capital–labour ratios that are quite similar in the two countries, the relative MFP is quite close to the relative level of labour productivity. The aggregate level of MFP in the Canadian total economy was 87.6% of the U.S. level in 1999.

The similarity in the capital–labour ratio between Canada and the United States masks considerable differences in the type of assets used in each country. In 1999, the ratio of structure capital to labour in Canada was 130% of the same ratio in the United States. The ratio of machinery and equipment (M&E) capital to labour in Canada was 78% of that in the United States. Factor proportions for the total Canadian economy are quite different than for the U.S. economy, at least when it comes to the composition of capital.

3. What are the trends in relative Canadian-U.S. levels of labour productivity, MFP and capital intensity in the total economy for the period from 1994 to 2003?

Before 2000, the relative level of labour productivity in Canada and the United States experienced little change. During the 1994-to-2000 period, the aggregate level of labour productivity in Canada was about 90% of the U.S. level. After 2000, the relative level of labour productivity in Canada declined from 90% of the U.S. level in 2000 to 87% of the U.S. level in 2003.

The aggregate level of MFP in Canada relative to that in the United States increased over the 1994-to-2000 period and then it declined slightly after 2000. It rose from 85% in 1994 to 90% in 2000, and then declined to 89% in 2003. At the same time, the aggregate level of capital–labour ratio declined in Canada relative to that in the United States. The decline was a result of the lower growth in structure and equipment capital stock and a higher growth in hours worked in Canada.

4. What are the sources of the Canadian-U.S. labour productivity level differences in the total economy?

We have decomposed labour productivity differences between Canada and the United States into contributions arising from differences in MFP and differences in capital intensity. The lower level of Canadian labour productivity relative to that of the United States was due to the lower MFP level in Canada. The capital intensity was similar in the two countries, which is a result of higher structural-capital intensity on the one hand and lower equipment-capital intensity in Canada on the other hand.

The aggregate level of labour productivity in Canada was 10% behind that of the United States in 1999. The lower level of MFP in Canada lowered the relative level of labour productivity in Canada by 12%. The lower level of M&E capital–labour ratio lowered the relative labour productivity in Canada by 4%, while the higher level of structure capital–labour ratio increased Canadian relative labour productivity by 6%. Overall, the capital intensity in Canada was slightly higher in 1999, which raised Canadian labour productivity by 2%.

5. What are the relative Canadian-U.S. levels of labour productivity, MFP and capital intensity at the sector level?

Relative Canadian-U.S. labour productivity levels vary considerably in the four major sectors of the total economy: engineering, goods, services and non-business sectors. The first three sectors make up the total business sector. The non-business sector includes the government sector, the health and education sector and owner-occupied dwellings.

The level of labour productivity in the Canadian business sector was about 84% of the U.S. level in 1999. But this aggregate hides considerable differences across the various sectors.

The level of labour productivity in the Canadian non-business sector was similar to that in the United States, as it should be since output is basically equal to inputs in the public sector, by construction, and the purchasing power parity (PPP) is calculated here from relative factor costs.

The service sector in Canada had the lowest labour productivity level relative to that in the United States—at 76% in 1999. The engineering sector, on the other hand, had the highest relative productivity (99%) in 1999. The goods sector in Canada was at 81% of American labour productivity in 1999, above the relative level of the service sector but considerably below the engineering sector.

The engineering sector in Canada was much more capital intensive than its U.S. counterpart in 1999. The goods sector in the two countries had similar capital–labour ratios in 1999, while the Canadian service sector was less capital intensive than its U.S. counterpart. When capital intensity is considered and MFP is estimated for the three sub-sectors of the business sector, the sectors move closer to one another because the relative capital intensity of the engineering and goods sectors in Canada are above that of the service sector.

The service and goods sectors in Canada had lower levels of MFP relative to those of the United States and were behind the United States by about 20% in 1999. The engineering sectors had a higher relative MFP level, behind the United States by 15% in 1999.

6. What are the sources of the Canadian-U.S. labour productivity level differences at the sector level?

The lower level of labour productivity in Canada relative to the United States in 1999 was mainly due to the lower level of MFP in all three major sectors: goods, services and engineering sectors. The lower M&E capital intensity was also a factor behind the lower labour productivity level in the Canadian engineering and services sectors but not in the goods sector. The higher structure-capital intensity in Canada increased the relative level of labour productivity in the three major sectors, and the effect was larger in the engineering sector and was smaller in the goods and service sectors.

7. What are the industry origins of the lower levels of labour productivity and MFP in the Canadian economy relative to the United States?

The lower level of labour productivity and MFP in the Canadian service sector accounted for most of the labour productivity and MFP differences between Canada and the United States in 1999. This is a result of the service sector having the lowest relative levels of labour productivity and MFP in Canada and having the largest share of output and hours worked in the total economy.

8. What is the range of relative Canadian-U.S. MFP levels estimates in the total economy?

The relative MFP-level estimates are derived from constructs that measure output, labour and capital and that are combined analytically in the MFP estimates using weights on both relative capital and labour inputs. Our estimates of each of the variables are subject to error and, therefore, the point estimates of MFP are subject to a degree of uncertainty.

To provide the reader with guidance on the nature of the range within which the true estimate is likely to be found, the paper considers sequentially alternative estimates of PPPs, error margins in our estimates of the relative levels of capital–labour ratios and possible differences occasioned by the choice of different weights in aggregating investments in M&E and structures. The paper finds that the Canadian MFP level in the total economy likely ranges from 86% to 96% of the U.S. level in 1999.

1 Introduction

The productivity program of Statistics Canada has traditionally focused on estimating the rate of **growth** of productivity—using both partial and multifactor productivity (MFP) measures. By means of its analytical program, it provides information to users on cross-country differences in productivity **growth** rates between Canada and the United States.

Statistics Canada's analytical focus on comparisons of Canadian-U.S. **growth** rates rather than on **levels** is done because the problems in comparing growth rates across countries are felt to be less than the problems in comparing levels. Estimates of output have been harmonized as countries have moved toward adopting the international standard outlined in the System of National Accounts (1993). But there are still differences in methods and coverage of other variables that are required to compare productivity levels across countries in the areas of labour and capital. Even though sources and methodology used to measure labour and capital differ across countries, when they are held constant over time, these different sources may yield reasonably accurate estimates of the relative magnitude of productivity **growth** across countries. In contrast, these differences make the comparison of productivity **levels** more problematic.

Because of these difficulties, cross-country comparisons are usually made by analysts outside of statistical agencies. Many analysts who attempt these comparisons often request guidance from Statistics Canada on the nature of the problems that they should consider when interpreting the meaning of cross-country differences in productivity levels, and how they might be resolved—since statistical agencies are uniquely situated to understand the difficulties involved in comparing data from different countries and how differences in methodologies can be reduced.

A previous paper (Baldwin et al. 2005) explored the problems that needed to be resolved in order to produce estimates of the level of Canada's labour productivity relative to the United States. Existing estimates of the gap in the level of labour productivity were so diverse that an effort was made to provide standardized data that could be used to better estimate the level of labour productivity between Canada and the United States.

The same problem exists with regard to different estimates of the level of MFP in Canada compared with the United States. For example, Jorgenson, Ho and Stiroh (2005) compare the MFP levels among G7 countries—Canada, France, Germany, Italy, Japan, the United Kingdom and the United States—and estimate the level of MFP in the Canadian economy as being 10% higher than that of the United States in 2001. In contrast, Rao, Tang and Wang (2004) report the MFP level was 13% lower in Canada in 2001 in the business sector.

This paper attempts to inform this discussion by examining the level of MFP in Canada relative to that of the United States using data that are especially constructed for this purpose to provide somewhat more comparability than has existed in the past.[1]

1. See Schreyer (2005) for a similar attempt to standardize for cross-country differences. Schreyer's work does not, however, standardize for differences in labour or enable sectoral comparisons, as are done here.

The relative labour productivity level measures the relative efficiency with which the two economies transform labour into output. But the relative labour productivity level captures only one dimension of the relative efficiency of the production system. The overall efficiency of the production system also depends on the efficiency with which capital is being used in the two countries. The relative MFP level compares the relative output differences across two countries—not just to labour input differences but also to capital input differences—and thus it provides a more 'complete' measure of overall efficiency. The relative MFP level captures the difference in the overall efficiency of an economy that arises from the use of superior production techniques, technology, firm organization, firm scale and labour quality.

In addition to providing an estimate of the relative level of Canadian-U.S. MFP, this paper relates the estimates of relative MFP to the estimates of relative labour productivity. The differences in labour productivity in the two countries can be decomposed into two components: a component that comes from differences in the amount of capital per worker and a component that comes from differences in MFP (overall efficiency). The decomposition allows us to examine the relative importance of differences in capital intensity and overall production efficiency in accounting for labour productivity differences between Canada and the United States.

Finally, the paper moves beyond the total economy (or the total business sector) that was examined in Baldwin et al. (2005). It examines differences in the relative Canadian-U.S. levels of productivity in different industries in order to estimate the contributions that individual industries make to the overall gap in MFP.

An estimate of the relative MFP level in Canada and the United States requires comparable data on outputs and inputs. To do so, the paper starts by choosing comparable data for labour, investment and output from the various sources that are produced by the statistical agencies in Canada and the United States. The paper then adjusts each, where required, to improve comparability and it applies similar methodologies to estimate capital input, labour input and industry output from the appropriate source data. For capital stock, the paper starts with the investment data by asset type and then uses the same methodology—the perpetual inventory technique using similar geometric depreciation rates—to estimate capital stock in the two countries. For labour input, the paper estimates hours worked using comparable methods and comparable microdata sources in the two countries (see Baldwin et al. 2005 for details). For output, the paper constructs a measure of output for U.S. industries that is calculated at basic prices that can be compared with the measure of output for Canadian industries that is calculated at basic prices.

The rest of the paper is organized as follows. The next section presents the methodology and data sources for comparing the levels of MFP between Canada and the United States. The methodology was first used by Jorgenson and Nishimizu (1978) to analyse relative productivity levels in Japan and the United States. Section 3 presents the results on relative productivity levels in Canada and the United States. Section 4 concludes the paper.

2 Method and data sources for the Canadian-U.S. multifactor productivity comparison

The relative multifactor productivity (MFP) level estimates are derived from a growth accounting framework that allows analysts to isolate the effects on the labour productivity level differences of the capital intensity differences. The relative MFP level is calculated as the residual portion of the labour productivity level difference that is not accounted for by the difference in the relative capital intensity. It measures the difference in production efficiency with which capital and labour are used in production in the two countries. The difference in this area arises from differences in technology, in firm organizational structure, the exploitation of scale economies and the skill levels of the labour force.

In this paper, we construct the relative MFP levels in the total economy in Canada and the United States. The difference in the MFP levels between Canada and the United States is expressed as the difference in the logarithms of output in the two countries, less a weighted average of the differences in the logarithms of capital and labour input in the two countries, with weights given by the average shares of inputs in the value added in the two countries,

$$\ln\left(\frac{MFP^C}{MFP^U}\right) = \ln\left(\frac{Y^C}{Y^U}\right) - \overline{v}_K \ln\left(\frac{K^C}{K^U}\right) - \overline{v}_L \ln\left(\frac{L^C}{L^U}\right), \qquad (1)$$

where MFP^C and MFP^U denote multifactor productivity in Canada and the United States, respectively; Y, K and L denote the value-added output, capital input and labour input; $\overline{v}_K$ and $\overline{v}_L$ are the average shares of value added that go to capital income and labour compensation in the two countries.

While the relative MFP level is a more comprehensive measure of the production efficiency difference in the two countries than the relative labour productivity level, the two are not independent of one another. The difference in labour productivity level between Canada and the United States can be decomposed into two components: one is due to the difference in MFP and the other arises from the difference in capital intensity in the two countries:

$$\ln\left(\frac{LP^C}{LP^U}\right) = \ln\left(\frac{MFP^C}{MFP^U}\right) + \overline{v}_K \ln\left(\frac{\left(K^C / L^C\right)}{\left(K^U / L^U\right)}\right), \qquad (2)$$

where LP denotes labour productivity level or the value-added output per unit of labour.[2]

The estimation of relative MFP levels starts with the comparison of the level of output and then requires estimates of the relative levels of capital and labour inputs. It is important to note that while MFP is a more comprehensive concept than labour productivity, it is also more complex to

2. Equation (2) can be derived from rewriting Equation (1). The two equations constitute two main equations for the growth accounting framework used to measure the relative multifactor productivity level difference.

estimate. Labour productivity estimates only require measures of output and labour. Even here, our previous paper suggested that devising an accurate measure of relative labour productivity in Canada required the development of comparable labour data and price deflators. Moreover, any point estimate should be accompanied by a confidence interval to guide users on the size of the band within which the true estimate might fall.

In the case of a MFP estimate, there are additional issues that an analyst needs to address. First, capital needs to be estimated. To do so, information needs to be acquired, or assumptions need to be made, on the length of life of assets and on the depreciation rates of investments. If the concept of capital services is going to be used in lieu of capital stock, rates of return need to be estimated. Since countries tend to use different assumptions, cross-country comparisons need to standardize assumptions in order to reduce the differences that arise from different techniques.

An additional problem faced by the analyst who sets about estimating Equation (1) is the choice of weights $\overline{v}_K$ and $\overline{v}_L$ that are used to aggregate labour and capital. In a time series context, these weights are meant to approximate the marginal products of labour and capital—since MFP is just the difference between the actual change in output and that which would have been expected, given changes in inputs. The latter is determined by the additional product that existing production techniques would have produced from the increase in inputs, and it is determined by existing marginal products of each input. The non-parametric techniques that are used by Statistics Canada and the Bureau of Labor Statistics (BLS) to estimate MFP **growth** rates assume constant returns to scale in the production function and that factors are paid their marginal product to derive these weights from the share of each input (labour and capital) in total income. This paper uses the same methodology to estimate the relative level of Canadian and U.S. MFP.[3]

These weights can be, and are, chosen in other ways. Some use econometric estimation techniques of production and/or cost functions to derive estimates of the weights. And the estimates in this case are sometimes different from the cost shares. These differences can result in different estimates of cross-country MFP levels. The extent of these differences will be examined in a subsequent section that calculates the sensitivity of the estimates presented here to alternate methodologies.

In the rest of the section, we discuss the methods and the data sources that are used to estimate the Canadian-U.S. relative levels of output, capital input and labour input that enter the formula for relative MFP (Equation 1).

2.1 Output

While both Canada and the United States adhere to international standards when producing estimates of gross domestic product (GDP)—the System of National Accounts (1993)—there are some differences in the statistical systems of the two countries that have to be addressed by researchers who are comparing output levels.

3. At issue is not whether these assumptions are exactly true, but whether deviations from them have a meaningful impact on multifactor productivity estimates.

The first issue that has to be addressed is the comparability of industry estimates of GDP, since this paper goes beyond the total economy and the total business sector to examine differences at the industry level. This paper makes use of data on output per industry derived from the Bureau of Economic Analysis (BEA).[4] Both Statistics Canada and the U.S. BEA have adopted the same industrial classification—the North American Industry Classification System (NAICS)—in their estimation of industrial output. But some differences in industrial coverage remain. One major difference is the finance, insurance and real estate (FIRE) sector. This sector in the United States includes the rent from rental and owner-occupied residential building; whereas in the Canadian productivity accounts, the sector includes only the rent from rental residential buildings, but not the imputed rent from owner-occupied dwellings. For the purpose of output-level comparisons, we have moved the imputed rent of owner-occupied dwellings to the value-added output from the U.S. FIRE sector to the U.S. non-business sector.

The next issue that needs to be addressed is the valuation of output for a Canadian-U.S. comparison of MFP levels. In our previous paper, we compared Canada with the United States at the level of the total economy. At this level, both Canada and the United States produce estimates of total output (GDP) using similar price concepts—GDP measured at market prices. But this paper will move to the industry level, and here Canadian and U.S. practices differ. Statistics Canada values industry output at basic prices while BEA values industry output at market prices. The difference between the two measures of outputs is taxes and subsidies on products. The difference can be quite large for some industries. Baldwin et al. (2005) report that the value of output at market prices was about 7% higher than the value of output at basic prices in the Canadian business sector in 1999. For the Canadian manufacturing sector, the difference between the two measures of output was 20%.

To derive comparable measures of output at the industry level for our comparisons of Canada and the United States, we have estimated output at basic prices for the U.S. industries that can be used to compare with the Canadian industry measures that are calculated in basic prices. To derive such a measure, we have subtracted net product taxes from industry output measures that are calculated at market prices. BEA does not publish net product taxes at the industry level. Instead, it publishes the taxes on production and imports at the industry level, which include both product taxes and property taxes. In this paper, we have estimated taxes on product at the industry level as the difference between the taxes on production and imports and a measure of property taxes at the industry level, which is estimated using the industry distribution of net capital stock and total property taxes published by BEA. A similar approach is used by BEA to allocate the total property taxes among industries (Moyer et al. 2004).[5]

Alternatively, we can construct estimates of output at factor cost for the two countries as in Rao, Tang and Wang (2004) or estimates of output at market prices. Such measures are less comparable than the measures adopted here for the purpose of international comparison (Lal 2003). First, GDP at factor costs in the petroleum industries includes gasoline taxes in the United

4. We use the Bureau of Economic Analysis data because this agency is responsible for the National Accounts and produces a complete set of industry output data. The agency that produces estimates of productivity growth rates (the Bureau of Labor Statistics) does not produce a complete set of estimates for individual industries (Triplett and Bosworth 2004).

5. Total property taxes are published in the National Income and Product Accounts, Table 3.5.

States, while it does not in Canada. The use of GDP at factor cost will show a large productivity gap in the petroleum industries in the two countries. Second, GDP at market prices for the U.S. wholesale and retail trade sectors includes taxes on all imports, and about 20% of GDP in those industries are product and import taxes in the United States. The use of GDP at market prices will show much lower level of productivity in the Canadian wholesale and retail trade sectors relative to those of the United States.

The third issue that needs to be addressed is the choice of a price unit that is to be used to compare Canadian with U.S. GDP, each of which is produced in the national currencies—Canadian and U.S. dollars, respectively. In order to compare outputs between Canada and the United States that are calculated in their respective dollar currencies, we need price deflators to transform relative values of GDP measured in dollars to measures of relative real output. Relative price indices that are referred to as purchasing power parities (PPPs) are used for this purpose. These PPPs are calculated using final or market prices in the two countries.

These market-price PPPs are then adjusted to be consistent with the basic-price concept of output used for this paper. The adjustment is based on relative product tax rates between Canada and the United States—or the ratio of GDP at market prices to GDP at basic prices—for the total business and non-business sectors.

Our previous paper (Baldwin et al. 2005) discusses the problems that arise in this area when the PPPs that are traditionally used for comparing levels of expenditures across countries are used to compare levels of productivity. There we focused on the difficulty of inferring export prices from prices obtained from domestic expenditures. An additional problem arises here because we move to compare productivity levels at the industry level. PPPs in the the official Statistics Canada PPP program are calculated only for expenditures, not for industries.

For this project, we estimate experimental relative prices or PPPs of industrial output at the industry level for Canada and the United States by using data on relative prices for comparable products that are obtained from Statistics Canada's bilateral Canada–United States Purchasing Power Parity Program, a part of the Eurostat/OECD/UN International Comparison Program. The data contain relative Canadian-U.S. prices for 221 categories of goods and services (basic heading) that together comprise total final expenditure GDP. Underlying these categories are detailed prices for more than 2,000 items. These individual item price ratios are averaged to calculate the relative prices for basic headings (categories of goods and services). For example, under the basic heading 'rice,' there are 8 specifications of different types of rice. These basic headings are groups of similar, well-defined commodities constituting the most detailed level of commodity classification in the PPP program.

As industries produce a large number of products and use a large number of goods and services, individual PPPs at the commodity level have to be aggregated to obtain the PPPs for gross output, intermediate inputs and value added of an industrial sector. For that purpose, we use Fisher aggregation formulae that use output and intermediate inputs in Canada and the United States as weights.

We express PPPs between Canada and the United States as the price of one Canadian dollar's worth of a product in terms of U.S. dollars. The purchasing power parity for value added that uses output and intermediate inputs in Canada as weight is calculated as

$$PPP^L = \frac{\sum_j P_{V,j}^U V_j^C - \sum_j P_{M,j}^U M_j^C}{\sum_j P_{V,j}^C V_j^C - \sum_j P_{M,j}^C M_j^C}$$

$$= \frac{\sum_j (P_{V,j}^U / P_{V,j}^C) P_{V,j}^C V_j^C - \sum_j (P_{M,j}^U / P_{M,j}^C) P_{M,j}^C M_j^C}{\sum_j P_{V,j}^C V_j^C - \sum_j P_{M,j}^C M_j^C}, \quad (3)$$

where, PPP^L is the PPPs for value added; $P_{V,j}^U$ and $P_{V,j}^C$ are the prices of gross output j in the United States and Canada, respectively; $P_{M,j}^U$ and $P_{M,j}^C$ are the prices of intermediate input j in the United States and Canada, respectively; V_j^C and M_j^C are the quantities of gross output and intermediate input in Canada, respectively.

The prices of gross output and intermediate inputs in Equation (3) are expressed in domestic currency. The denominator is value added in Canada in nominal Canadian dollars. The numerator is the value added in Canada in terms of U.S. dollars.

The PPPs in (3) are calculated using Canadian output and inputs as weights and is referred to here as the Laspeyres PPP index. Similarly, we can calculate what we refer to here as a Paasche PPP index that uses U.S. output and intermediate inputs as weights. The Paasche index of PPPs for value added is

$$PPP^P = \frac{\sum_j P_{V,j}^U V_j^U - \sum_j P_{M,j}^U M_j^U}{\sum_j P_{V,j}^C V_j^U - \sum_j P_{M,j}^C M_j^U}$$

$$= \frac{\sum_j P_{V,j}^U V_j^U - \sum_j P_{M,j}^U M_j^U}{\sum_j (P_{V,j}^C / P_{V,j}^U) P_{V,j}^U V_j^U - \sum_j (P_{M,j}^C / P_{M,j}^U) P_{M,j}^U M_j^U}. \quad (4)$$

The Fisher index of PPPs is the geometric mean of the Laspeyres and the Paasche PPP indices. The 1999 Fisher PPP index for valued added is estimated. For this purpose, this paper employs the 1999 Canadian make-and-use tables, and the U.S. 1997 make-and-use tables.[6] Our methodology employs the 1999 PPPs for 221 commodities (or basic headings) that Statistics Canada collects for the Eurostat-OECD Purchasing Power Parity Programs (OECD 2002, Kemp 2002, Temple 2007).

6. The U.S. benchmark input–output tables are available every five years from the Bureau of Economic Analysis (BEA). The BEA also publishes annual input–output that has far less commodity detail.

The Canadian make-and-use table contains flows of 717 commodities by industrial sectors. The U.S. make-and-use tables contain flows of 483 commodities to industrial sectors. To estimate the Fisher index of PPPs, this paper first aggregates the commodities in the input–output tables of the two countries to a common aggregation—some 275 commodities. We then obtain the PPPs for this common set of commodities using the PPPs for 221 commodities in the Statistics Canada PPP program.

It is important to stress the difficulties that face this exercise since we do not want to misrepresent the quality of the estimate. This exercise is putting data to a use for which they were not originally designed. The list of commodities in the Statistics Canada PPP program is chosen to cover those that are used for final expenditures. They do not cover a wide range of commodities of all industries in the NAICs classification system. And there are substantial areas where there are no PPPs collected. In cases where no data exist, averages from the rest of the file are used in the PPP program.

While output price data are not available everywhere, the problem is greater on the input side. Commodities that are used for intermediate inputs are not included in the program. For this paper, PPPs for input commodities are derived through reference PPPs. These are PPPs based on price data that have been collected for other basic headings and that serve as proxies for the missing PPPs. For the missing PPPs of the commodities whose prices are determined in international markets, the 1999 exchange rate was chosen as a proxy.[7]

For the non-business sector, such as education, health and other government services, the price of output is not observed due to the lack of market transactions. In the Canadian and U.S. National Accounts, the value of output of the non-business sector is calculated as the sum of costs that are incurred in production. To maintain consistency with the prices underlying those expenditures, it is necessarily to use the prices of inputs to calculate the PPPs for the output of the non-business sector. This is the so-called 'input-based approach' for calculating PPPs (OECD 2002). As the costs of the non-business sector consist of compensation of employees and gross operating surplus, the PPP for the non-business sector is a weighted-average of PPPs derived using the compensation of employees and gross operating surplus in each of the non-business sectors.

2.2 Labour input

Labour input in this paper is measured as the number of hours worked.[8] Baldwin et al. (2005) developed a comparable estimate of hours worked for Canada and the United States for

7. Baldwin and Yan (2004) report that for tradables, there is no significant difference between the average purchasing power parity and the exchange rate in 1999.
8. In contrast, labour input in the Statistics Canada's multifactor productivity growth programs takes into account the skill difference among workers and is constructed as a weighted sum of hours worked across different types of workers with weights based on relative compensation rates.

estimating the relative level of labour productivity in the two countries. These estimates are used herein.[9]

The hours worked for the United States is estimated as the sum of hours worked of paid workers and that of self-employed workers. The hours worked of paid workers is measured as the product of total number of jobs and hours worked per job. Similar to the Bureau of BLS method for estimating hours worked of paid workers, Baldwin et al. (2005) use establishment reports from the BLS Current Employment Statistics (CES) program for estimating the number of jobs of paid workers. The number of jobs that Baldwin et al. (2005) have estimated from the CES is almost identical to the estimates from the BLS. As such, we have used the number of jobs of paid workers by sector from the BLS for estimating total number of hours worked.[10]

The main departure from the BLS method relates to the estimation of hours worked per job for paid workers. The BLS uses the establishment survey (CES) to estimate hours worked per job for production workers and uses the household survey—Current Population Survey (CPS)—to estimate hours worked for supervisory and non-production workers (Eldrige, Manser and Otto 2004). In contrast, Baldwin et al. (2005) use the CPS to estimate U.S. hours worked per job for both production and non-production workers. They also employ the same methodology to extrapolate the estimate of hours worked from the week of the household survey to other weeks in the month—by taking into account holidays, either during the week of the survey or during other weeks in the month. This method is chosen so that the estimated hours worked for the United States are comparable with the estimates for Canada. Using U.S. estimates from the enterprise survey (CES) and the Canadian estimates from the household survey would bias the hours worked in Canada up relative to the United States, since household surveys tend to give a higher estimate of hours worked than do enterprise surveys (Baldwin et al. 2005).[11]

The effect of using CPS for estimating hours worked for all paid workers is to increase the total number of hours worked in the total economy in the United States by about 5% a year for the 1994-to-2004 period.[12]

The hours worked of self-employed is estimated as the product of the number of jobs and the hours worked per job. Both BLS and Baldwin et al. (2005) use CPS to estimate hours worked of self-employed workers. The number of jobs is benchmarked at the major sector level to the total number of jobs for self-employed workers from BLS.[13]

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9. The measure of relative level of labour input in this paper does not take into account the differences in the composition of workers in the two countries. The construction of such a measure will be the focus of future research.
10. The data on the number of jobs of paid workers were sent to us by P.F. Otto and Shawn Sprague of the Bureau of Labor Statistics. These correspond to the total number of jobs of paid workers used by Baldwin et al. (2005).
11. Baldwin et al. (2005) also argue that hours worked from household surveys are better able to capture the hours worked but not paid and therefore more accurately capture the concept of work specified in the System of National Accounts (1993).
12. Baldwin et al. (2005) provide corroborating evidence from time use surveys in both countries of their hours worked estimates derived from the labour force surveys.
13. The Bureau of Labor Statistics does not produce the number of jobs at the sector level.

The labour income data from BEA is adjusted to include the compensation of self-employed. The adjustment is made using the assumption that the self-employed earn compensation equal to that of employees in the industry.[14]

2.3 Capital input

This paper's major contribution on the input side is to generate more comparable measures of capital services than have been used in previous studies. As was the case for labour inputs, Canada and the United States use similar but not identical methods for estimating the rate of growth of capital inputs in their respective MFP **growth** programs. While these differences have little impact on comparisons of **growth** rates, they affect the precision of the estimates of **level** differences. Estimates are generated for this study that use a similar methodology for Canada and the United States.

To estimate the relative level of capital services in Canada and the United States, we take into account the difference in the composition of capital stock (equipment versus structures) in the two countries. The method for measuring the difference in capital services between the two countries is similar to the one for measuring the changes in capital services over time within a country.[15] The difference between logarithms of capital services for Canada and the United States is calculated as

$$\ln\left[\frac{K^C}{K^U}\right] = \sum_j \overline{v}_{K,j} \ln\left(\frac{Z_j^C}{Z_j^U}\right), \tag{5}$$

where

$$\overline{v}_{K,j} = \frac{1}{2}(v_{K,j}^C + v_{K,j}^U)$$

$$v_{K,j}^i = \frac{c_j^i Z_j^i}{\sum_j c_j^i Z_j^i}, \quad i = C,U.$$

K^i in the equation is capital services in country i; i indexes country and equals C for Canada and U for the United States; Z_j^i is capital stock of asset type j in country i; c_j^i is user cost of capital for asset type j in country i.

14. Triplett and Bosworth (2004) used a similar approach to adjust the labour income data from the Bureau of Economic Analysis.

15. The main differences relate to the asset details. The capital services estimates in the multifactor productivity estimates of Statistics Canada and the Bureau of Labor Statistics have much more asset details and include land and inventories in the estimates. The capital services in this paper are estimated from two types of assets: equipment and structures. For the method for measuring changes in capital services over time in Canada, see Baldwin and Gu (2007a) and Harchaoui and Tarkhani (2003).

As the price of capital services times the quantity of capital services equals the value of capital services, the relative price of capital services between Canada and the United States can be written as

$$\frac{c^C}{c^U} = \frac{\sum_j c_j^C Z_j^C}{\sum_j c_j^U Z_j^U} \frac{K^U}{K^C} \quad . \tag{6}$$

The user cost of capital can be thought of as the price that a well functioning market would produce for an asset that is being rented by an owner to a user of that asset. That price would consist of a term reflecting the opportunity cost of capital or rate of return (r_t), a term reflecting the depreciation of the asset (δ), and a term reflecting capital gains or losses from holding the asset (reflecting changes in the market price of an asset $q_t - q_{t-1}$). Jorgenson (1967) shows that the formula for the rental price of a unit of capital that costs q is

$$c_{j,t}^i = q_{j,t}^i r_t^i + q_{j,t}^i \delta_j - (q_{j,t}^i - q_{j,t-1}^i) \, . \tag{7}$$

The rate of return can be derived from a formula that sets the sum of user costs across asset types equal to total capital income. In this case,

$$\sum c_{j,t}^i K_{j,t}^i = \sum [q_{j,t}^i r_t^i + q_{j,t}^i \delta_j - (q_{j,t}^i - q_{j,t-1}^i)] K_{j,t}^i = \textit{Capital Income} \tag{8}$$

and substituting values of K derived from the perpetual investment estimate of capital, δ for depreciation, and $q_t - q_{t-1}$ for market price changes in the asset in Equation (6) allows the rate of return r_t to be derived endogenously.

Alternatively, the rate of return can be chosen exogenously as the cost of financing capital expenditures in capital markets—some combination of debt and equity costs. In this paper, we will use the former method for determining the rate of return in the user cost of capital estimation.

The capital stock of each asset type is constructed using the perpetual inventory technique. Assuming a geometric declining pattern, we obtain

$$Z_{j,t}^i = I_{j,t}^i + (1 - \delta_j) Z_{j,t-1}^i \, , \tag{9}$$

where $I_{j,t}^i$ is investment in asset type j in country i in period t. δ in Equation (9) is the geometric rate at which the efficiency of an asset declines over time.

The capital stock and investment in Equation (5) are expressed in a common currency (Canadian dollars in this paper). However, data on investment for Canada and the United States are available only in domestic currency. To make the capital stocks of the two countries comparable, we have constructed PPPs for each type of investment good. Our procedure calculates each

country's capital stocks in 1999 dollars and then uses the 1999 PPP to provide a level of relative real capital stock.[16]

It is important to note here that PPPs in the area of investment goods are notoriously difficult to estimate for many cross-country comparisons and are therefore subject to measurement error. It has been observed that machinery used in one country is often different from that in another. This should be less of a problem for a Canadian-U.S comparison than it is for comparisons of European countries with either Canada or the United States. But it is still the case that outside of machinery and equipment (M&E), PPPs for structures and engineering are sparse. At one time, they were accumulated by using engineering firms to cost out similar models of buildings and some engineering works (highways), but this method has lapsed in recent years.

The main data source for estimating capital services in Canada is investment data in the MFP program of Statistics Canada (Baldwin, Gu and Yan 2007). These data contain investment in current dollars and Fisher quantity indices over the 1926-to-2003 period for 28 assets as listed in Table 1.[17]

The main data source for estimating capital services in the U.S. business sector is investment data by industry based on NAICS over the 1901-to-2005 period.[18] These data are obtained from BEA and contain investment for 47 assets. The investment for the U.S. government sector has data for three assets: M&E, building structures and engineering structures.[19]

Investment data for Canada and the United States are not perfectly comparable at the industry level. Both Canada and the United States collect detailed data on commodities for the economy as a whole. Some of these are classified as investment goods. Canada also has an investment survey that is used to spread the economy-wide totals derived from the commodity totals by industry of ownership of the capital. The United States spreads the total investment of M&E mainly by using occupational data (Haltiwanger 2006). Construction expenditure is obtained directly by industry from a special survey. All of this means that researchers need to be careful when comparing capital stock using fine levels of industry detail. However, for this paper, we have chosen very aggregative sectors to reduce the extent of non-comparability.

16. An additional problem that has not been addressed here is differential tax rates on investment in Canada and the United States. Up to the early 1990s, Canadian investments faced federal sales taxes as well as provincial sales taxes. At present, provincial sales taxes are still levied in the majority of provinces.
17. The data from 1926 to 1960 contain investment for three assets (machinery and equipment, building structures and engineering structures). To obtain investment for the 28 assets over the 1926-to-1960 period, we assume that share of investment by asset type over that period is the same as the one averaged over 1961, 1962 and 1963.
18. See Lally (2004) for a discussion of the data.
19. We make use of current dollar and constant dollar estimates from Statistics Canada and from the Bureau of Economic Analysis and do not impose a similar deflator for computers as is done in Schreyer (2005) for his comparison of North America and Europe, since the latter is less likely to use hedonics for computers than is North America. However, both Canada and the United States use hedonics to estimate the price deflator for computers and differences are therefore felt to reflect legitimate differences in market pricing behaviour.

Table 1
The list of assets and depreciation rates

Name	Final
Office furniture and furnishing	0.24
Non-office furniture, furnishings and fixtures	0.21
Motors, generators and transformers	0.13
Computer-assisted process	0.17
Non-computer-assisted process	0.16
Communication equipment	0.22
Tractors and heavy construction equipment	0.17
Computers, associated hardware and word processors	0.47
Trucks, vans, truck tractors, truck trailers and parts	0.23
Automobiles and parts	0.28
Other machinery and equipment	0.20
Electrical equipment and scientific devices	0.22
Other transportation equipment	0.10
Pollution abatement and control equipment	0.15
Software	0.55
Plants for manufacturing	0.09
Farm building, maintenance garages and warehouses	0.08
Office buildings	0.06
Shopping centres and accommodations	0.07
Passenger terminals and warehouses	0.07
Other buildings	0.06
Institutional building construction	0.06
Transportation engineering construction	0.07
Electric power engineering construction	0.06
Communication engineering construction	0.12
Downstream oil and gas engineering facilities	0.07
Upstream oil and gas engineering facilities	0.13
Other engineering construction	0.08

Source: Statistics Canada, Depreciation Rates for the Productivity Accounts.

In the non-business sector, there is one major difference between the practices followed in the two countries. Canada treats all military equipment as an intermediate expense while the United States treats them as an investment and therefore capitalizes them.

The level of capital stock is sensitive to the depreciation profiles and depreciation rates that are used to estimated capital stock. To develop comparable measures of capital stock and capital services, we have used geometric depreciation profiles and the depreciation rates for Canada and the United States, as listed in Table 1. The depreciation rates in the table are derived from Statistics Canada research that estimates depreciation profiles for a diverse set of assets that employs used asset prices derived from a Statistics Canada survey (Statistics Canada 2007). The resulting depreciation rates are on average the same as those used by BEA for machinery and equipment. They are slightly higher for buildings and engineering construction.[20]

20. Choosing Bureau of Economic Analysis rates across all categories does not change the results reported here in a material way. What is important is that both Canadian and U.S. capital stock be derived from a similar set of depreciation rates.

To estimate capital stock, we also need to choose an initial value of capital stock. For Canada, capital stock is estimated using the historical investment over the 1926-to-2003 period. For the United States, capital stock is estimated using the historical investment over the 1901-to-2005 period. The choice of initial capital stock in 1926 for Canada and in 1901 for the United States will have little effect on capital stock estimates for the period from 1994 to 2003 that is used in this paper.

In this paper, we have adopted the definition of the FIRE sector that includes the rents of rental housing but excludes imputed rents of owner-occupied dwellings. To be consistent with that definition of the FIRE sector, we have included investment in rental housing in the FIRE sectors and included investment in owner-occupied dwellings in the non business sector.

2.4 Input weights

Estimation of the inter-country MFP requires weights that average the Canadian-U.S. differences in relative labour and capital inputs. In this paper, we adopt the same strategy that is utilized in Statistics Canada's MFP growth program and estimate these weights from the share of each input in factor income. This is also the approach taken in Jorgenson's cross-country comparisons (1995). As confirmation of the weights, we estimated a production function on 37 industries using the Canadian Capital, Labour, Energy, Materials and Services (KLEMS) database and pooled cross-section data from 1981 to 1997. The 37 industries correspond to the 47 M-level aggregation with government, health, education and owner-occupied dwellings and 8 other industries excluded where the data quality did not support estimation. Inputs include hours worked, and the capital services provided by M&E, engineering construction and buildings. When constant returns to scale are imposed, 3 of the 4 coefficients were not significantly different from their cost shares (Table 2).

Table 2
Input weights from estimation of production function

	Regression coefficient		Cost shares	Test
Input				Column 1= 2
Building construction	0.14	(4.64)*	0.09	Cannot reject
Engineering construction	0.06	(3.51)*	0.11	Reject
Machinery and equipment	0.13	(4.30)*	0.14	Cannot reject
Hours worked	0.68	(28.33)*	0.66	Cannot reject

* significant at 5% or better
Note: Absolute value of z-statistics are in parentheses.
Source: Statistics Canada, Capital, Labour, Energy, Materials and Services Database.

3 Canada–United States comparison of multifactor productivity

3.1 Industry aggregation

In this section, we will examine Canadian-U.S. differences at both the aggregate level and at the industry level. We have divided the total economy into four major sectors: the engineering sector, the goods sector, the service sector and the non-business sector, as listed in Table 3. The goods sector includes agriculture and manufacturing. The services sector includes wholesale and retail trade; finance, insurance and real estate; professional, scientific and technical services; management of companies; administrative and waste management services; arts, entertainment and recreation; and accommodation and food services. We also group together the forestry, fishing, hunting and mining industries; utilities; construction; transportation and warehousing; and, information and communication into what we call the engineering sector.[21]

Table 3
List of industries by sector

	1997 NAICS[1]
Engineering sector	
Forestry, fishing, hunting and mining and oil and gas extraction	113, 114, 115, 21
Utilities	22
Construction	23
Transportation and warehousing	48-49
Information and cultural industries	51
Goods sector	
Agriculture	111, 112
Manufacturing	31-33
Service sector	
Wholesale trade	41
Retail trade	44-45
Finance, insurance, real estate and rental and leasing[2]	52, 53
Professional, scientific, and technical services	54
Management of companies and enterprises	55
Administrative and support, waste management and remediation services	56
Arts, entertainment, and recreation	71
Accommodation and food services	72
Other services, except public administration	81
Non-business sector	
Public administration	91
Educational services	61
Health care and social assistance	62
Owner-occupied dwellings	...

... not applicable
1. North American Industry Classification System.
2. Excludes owner-occupied dwellings.
Source: North American Industry Classification System 1997.

21. We group them together because a substantial part of own-account production in utilities, communication and transportation in Canada is transferred to the construction sector.

There are substantial differences in the capital structure of each sector. While capital investments are most commonly associated with machinery and equipment (M&E), there is far more capital stock in buildings and in engineering construction taken together than there is capital stock in M&E. For the economy as a whole, some 21% is in M&E in 1999, some 55% is in buildings and 24% is in engineering construction (Table 4). The latter is a catch-all category that covers expenditures that do not fall neatly into the first two groups. Rail lines are not machinery and are not buildings and are classified in the engineering category. Hydro facilities may have some machinery (turbines) and buildings embedded in them but have so much other construction that it dwarfs the first two. Engineering construction is the infrastructure of those industries that themselves provide the networks on which the economy is based—utilities that manufacture and distribute power, transportation systems that link producers via goods flows and communications systems that permit information to be exchanged that are keys to the production process.

Table 4
Asset composition of nominal capital stock by sectors in Canada, 1999

	Machinery and equipment	Engineering structure	Building structure
	percent		
Engineering sector	28.2	63.3	8.5
Goods sector	64.3	9.3	26.4
Service sector	25.0	0.6	74.3
Non-business sector	3.5	18.7	77.8
Total economy	20.7	24.4	54.9

Source: Statistics Canada, Capital, Labour, Energy, Materials and Services database.

There are considerable differences in the capital structure of each of the sectors. For the goods sector (manufacturing and agriculture), machinery and buildings make up 64% and 26%, respectively, of capital. In the service sector, machinery and buildings make up 25% and 74% of capital, respectively. In the engineering sector, machinery makes up 28% but engineering works make up 63%, while buildings make up only 9%. Because of these differences, Canadian-U.S. comparisons of relative factor use need to ask the source of any differences found at the level of the overall economy. Differences in M&E for the total economy may originate primarily in those industries where this form of capital is important, or elsewhere.

The results at the industry level shed light on the industrial sources of overall Canadian-U.S. productivity differences. We are interested in determining whether the deficiency or superiority of the Canadian economy comes more from the goods sector—17% of 2003 gross domestic product (GDP)—where trade is large and our competitive trading advantage is immediately affected by lagging productivity, or in the basic engineering industries—23% of 2003 GDP—that provide foundational infrastructure for the economy as a whole, or in the service sector—34% of 2003 GDP—that has been growing at the expense of the other sectors over the last 25 years.[22]

The non-business sector in this paper includes the government sector and the health and education sector. The data for Canada and the United States are both based on the North

22. The non-business sector accounted for 26% of gross domestic product in Canada in 2003.

American Industry Classification System (NAICS). As such, the government sector (NAICS 91) includes public schools and public hospitals. The private and non-profit schools and hospitals are included in the education and health services sector of the business sector (NAICS 61 and 62).

It is sometimes argued that a comparison of the business sectors of Canada and the United States is problematic because most heath and education activity is classified as part of the non-business sector (the government sector) since schools and hospitals are generally public in Canada. In contrast, a much smaller portion of health and education in the United States is classified as part of the non-business sector because the United States has a larger share of private and non-profit schools and hospitals. Therefore, for the purpose of comparability between Canada and the United States, we have included all health and education activity in the non-business sector.[23]

3.2 Purchasing power parity estimates

The Laspeyres, Paasche and Fisher indices of 1999 purchasing power parities (PPPs) for value added and the 1999 PPPs for investment are presented in Table 5. The Fisher PPP will be used in this paper.

Table 5
Purchasing power parities for valued added and investment in 1999

	Laspeyres	Paasche	Fisher
		US$ per CAN$	
Purchasing power parities for value-added			
Business sector	0.84	0.81	0.83
Engineering sector	0.90	0.82	0.86
Goods sector	0.73	0.69	0.71
Service sector	0.88	0.86	0.87
Non-business sector	0.88	0.88	0.88
Total economy	0.86	0.84	0.85
Purchasing power parities for investment			
Machinery and equipment	0.76	0.75	0.75
Structures	0.94	0.93	0.94

Source: Statistics Canada, Purchasing Power Parity Program.

The PPPs for value added in Table 5 are adjusted for differences in product taxes between Canada and the United States and are based on the valuation of output at basic prices. This differs from the PPPs in Baldwin et al. (2005) and Maynard (2007), where PPPs reflect the differences in market prices in the two countries as the output is valued at market prices in those two papers.

The PPP between the U.S. dollar and the Canadian dollar measure of business-sector output is 0.83. This is similar to the PPPs in Baldwin et al. (2005). The PPP used here for output of the non-business sector is 0.88. Baldwin et al. (2005) use 0.98 as the PPP for output of non-business

23. The coverage of business sector industries is not entirely comparable in the two countries. The Bureau of Economic Analysis output at the industry level includes the output of non-profit institutions while the output in Canadian industries excludes the output of non-profit institutions.

sector. The difference between these estimates reflects recent revisions made to the PPPs for the output of the health and education sector. The PPP for output of the total economy is now 0.85 in 1999.

The PPP for the goods sector (0.71) is very close to the exchange rate in 1999 (0.67), which conforms with the results reported by Baldwin and Yan (2004) that tradable commodities were close to satisfying the law of one price in that year. On the other hand, the service sector's PPP (0.87) was well above the exchange rate in that year, once again conforming to the results for non-tradable commodities in that year (Baldwin and Yan 2004). Interestingly, the PPP for the engineering sector resembles the non-tradable rather than the tradable sector.

The PPP between the U.S. dollar and the Canadian dollar for M&E investment is 0.75 in 1999. The PPP for investment in structures is 0.94 in 1999. This means that relative to the United States, Canadian firms would have found M&E investment more expensive compared with investment in structures.[24]

3.3 Canada–United States comparison of productivity in the total economy

The relative efficiency of the Canadian economy in its use of both labour and capital can be gleaned in the first instance from the comparison of relative output and input levels. We present these comparisons in Table 6 for the total economy for the three years 1994, 1999 and 2003.[25]

Canadian output was around 9% that of the United States. Labour input as measured here was close to 10% and increased over the period. In contrast, capital services started at 11% and declined over the period slightly. But there were considerable differences in the relative amounts of capital. Canadian M&E was only around 8% that of the United States. On the other hand, structures—including both buildings and engineering—were around 13%. Canada therefore had relatively less capital in M&E and more in structures.

The aggregate level of labour productivity in Canada was about 89.8% of the U.S. level in 1999. The estimated labour productivity level in Canada relative to that in the United States is slightly lower than reported in Baldwin et al. (2005). The difference is a result of a downward revision of the official PPPs between the U.S. dollar and the Canadian dollar for the output of the non-business sector, due primarily to revisions in health and education sector wages.

24. The purchasing power parities (PPPs) for investment may differ by industry due to the difference in the composition of investment by asset types. In this paper, we assume that the PPPs for individual assets (equipment versus structures) are the same across industries.

25. The results for 1999 are our benchmark estimates and the results for other years are estimated using the benchmark estimates and relative growth rates in the two countries for the other variables.

Table 6
Relative Canadian-U.S. levels of output, inputs and productivity in the total economy

	1994	1999	2003
	United States = 100		
Output			
Value added	8.8	8.7	9.0
Inputs			
Hours worked	9.9	9.7	10.3
Capital services	11.4	10.4	10.3
Machinery and equipment capital stock	8.4	7.5	7.6
Structure capital stock	13.2	12.6	12.5
Capital services per hour	115.3	106.8	99.8
Machinery and equipment capital per hour	85.4	77.8	73.4
Structure capital per hour	134.3	129.9	121.6
Productivity			
Labour productivity	89.4	89.8	87.4
Multifactor productivity	84.9	87.6	86.9

Sources: Statistics Canada; and Bureau of Economic Analysis.

The capital–labour ratio in Canada has been essentially the same as that in the United States since 1999.[26] The similarity in the capital–labour ratio between Canada and the United States masks considerable differences in the type of assets used in each country. In 1999, the ratio of structure capital to labour in Canada was 130% of the same ratio in the United States. The ratio of M&E capital to labour in Canada was 78% of that in the United States. Factor proportions for the total Canadian economy are quite different than for the United States economy, at least when it comes to the composition of capital.

Previous studies that have examined Canadian-U.S. relative multifactor productivity (MFP) levels used the relative level of net capital stock. In this paper, we have used the relative level of capital services in our Canada–United States MFP comparison. The relative level of capital services is calculated as a weighted sum of relative levels of M&E and structure capital stock using weights based on the user cost of capital. Unlike the capital-stock approach, this user-cost approach takes into account the differences in the composition of capital stock—the relative size of M&E and structures in Canada compared with the United States. In comparison with the approach that uses capital stock to calculate the Canadian-U.S. relative level of MFP, the user-cost approach will assign larger weights to M&E with short service lives and lower weights to structures that have longer services lives because depreciation rates are higher for machinery than they are for structures. As such, the relative level of capital service tends to be higher than the relative level of capital stock in those countries with a larger share of M&E capital, such as the United States.

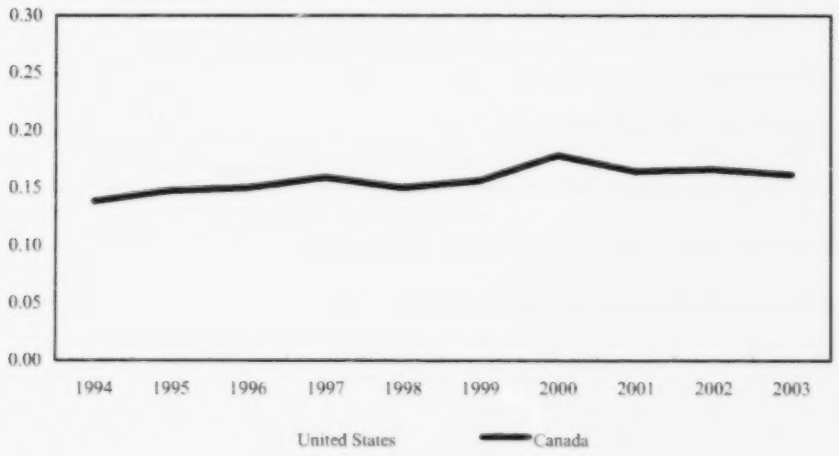
In our comparisons, we have adopted the endogenous rate of return method for calculating the user cost of capital.[27] One way of evaluating the sensibleness of this approach is to examine the relative rates of return that are so generated. Figure 1 plots own (or endogenous) rates of return

26. When we use the capital stock approach, we find that the aggregate level of capital–labour ratio in Canada was 107% of that in the United States in 1999.

27. Baldwin and Gu (2007a) have discussed methods for calculating the cost of capital in Canada.

to capital in Canada and the United States for the 1994-to-2003 period. These rates represent before-tax rates of return to capital. We find that the own rate of return to capital in Canada was slightly below that in the United States in 1994. The lower rate of return in 1994 in Canada, relative to the United States, reflects the deeper and longer recession that Canada experienced during the early 1990s. For the period from 1994 to 2003, the own rate of return to capital in Canada increased while the own rate of return in the United States declined. As a result, the own rate of return to capital in Canada was similar to that in the United States in 2003.[28]

Figure 1
Internal rate of return to capital in Canada and the United-States



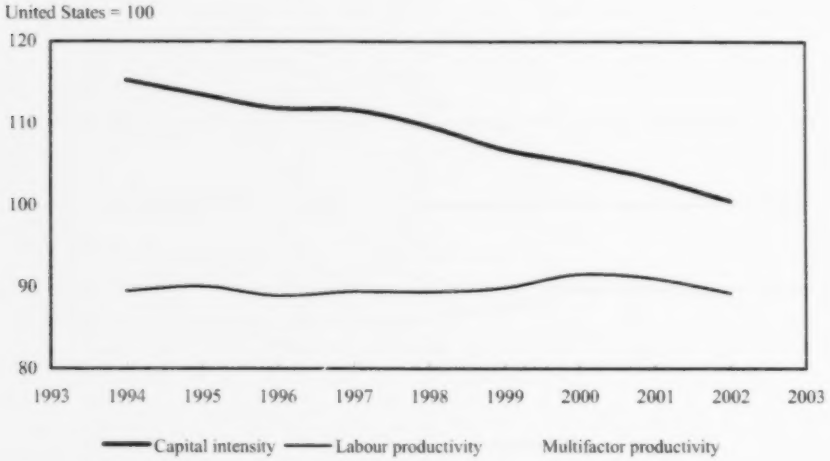
Sources: Statistics Canada; and Bureau of Economic Analysis.

With capital–labour ratios that are quite similar in the two countries, the relative MFP is quite close to the relative level of labour productivity. The aggregate level of MFP in the Canadian total economy was 87.6% of the U.S. level in 1999.

Before 2000, the relative level of labour productivity in Canada and the United States showed little change, as shown in Table 6 and Figure 2. During that period, the aggregate level of labour productivity in Canada was about 90% of the U.S. level. After 2000, the relative level of labour productivity in Canada declined from 90% of the U.S. level in 2000 to 87% of the U.S. level in 2003.

28. Dimson, Marsh and Staunton (2002) provide estimates of the cost of capital averaged over the period from 1900 to 2000 that show great similarities between Canada and the United States. Over the period, the real government bond rate averaged 1.8% in Canada and 1.6% in the United States—5.0% and 4.8% in nominal terms. Over the same period, equity rates of return were 9.7% in Canada and 10.1% in the United States. Similarities are also reported for the period from 1951 to 2000.

Figure 2
Relative Canadian-U.S. productivity and capital intensity in the total economy



Sources: Statistics Canada; and Bureau of Economic Analysis.

The aggregate level of MFP in Canada relative to that in the United States increased over the 1994-to-2000 period and then declined slightly after 2000. It rose from 85% in 1994 to 90% in 2000, and then declined to 89% in 2003. At the same time, the aggregate level of capital–labour ratio declined in Canada relative to that in the United States. The decline was a result of the lower growth in structure and equipment capital stock and a higher growth in hours worked in Canada (Baldwin and Gu 2007b).

We have decomposed labour productivity differences between Canada and the United States into contributions arising from differences in MFP and differences in capital intensity (Table 7). The lower level of Canadian labour productivity relative to the United States reflects the lower MFP level in Canada. The capital intensity was similar in the two countries, which is a result of higher structural-capital intensity and lower equipment-capital intensity in Canada.

Table 7
Sources of Canadian-U.S. labour productivity level differences in the total economy

	1994	1999	2003
Log difference in labour productivity (percent)	-11.2	-10.7	-13.5
Percentage point contributions of			
Log difference in machinery and equipment capital per hour	-1.9	-3.7	-4.6
Log difference in structure capital per hour	7.6	6.2	4.6
Log difference in multifactor productivity	-16.3	-13.2	-14.1

Sources: Statistics Canada; and Bureau of Economic Analysis.

The aggregate level of labour productivity in Canada was 10% behind that of the United States in 1999.[29] The lower level of MFP in Canada lowered the relative level of labour productivity in Canada by 12%. The lower level of M&E capital–labour ratio lowered the relative labour productivity in Canada by 4%, while the higher level of structure capital–labour ratio increased Canadian relative labour productivity by 6%. Overall, the capital intensity in Canada was slightly higher in 1999, which raised Canadian relative labour productivity by 2%.

Our findings on the sources of labour productivity level differences in Canada and the United States are consistent with the results in Schreyer (2005). Schreyer (2005) suggests that the Canadian-U.S. MFP difference accounted for 70% of the labour productivity difference in the two countries in 2003. Thus, it is not so much a lack of capital as an overall inefficiency with which resources are employed that explains the Canadian-U.S. labour productivity gap when comparisons are made of Canada and the United States using economy-wide data.

As we have already noted, this conclusion needs to be investigated further by examining relative productivity at the industry level, since the Canadian economy consists of different sectors that differ substantially in their use of different forms of capital. Some sectors may indeed be deficient in capital relative to labour and others may not. The next section therefore divides the Canadian and U.S. economies into major sectors and examines the relative Canadian-U.S. productivity levels in those sectors.

3.4 Canada–United States comparison of productivity at the industry level

Table 8 presents the relative levels of labour productivity, MFP and capital intensity in the four major sectors of the total economy in 1999. Relative Canadian-U.S. labour productivity levels vary considerably in the four major sectors of the total economy: engineering, goods, services and non-business sectors. The first three sectors make up the total business sector. The non-business sector includes the government sector, the health and education sector and owner-occupied dwellings.

Table 8
Relative Canadian-U.S. levels of productivity and capital intensity in major sectors, 1999

	Labour productivity	Multifactor productivity	Capital intensity		
			All	Machinery and equipment	Structures
Business sector	84.2	80.3	113.6	83.6	157.4
Engineering sector	98.7	85.4	143.1	79.6	261.3
Goods sector	81.2	79.7	104.7	95.3	135.1
Service sector	75.7	78.5	90.0	66.4	116.0
Non-business sector	106.8	105.3	103.6	37.8	126.7

Sources: Statistics Canada; and Bureau of Economic Analysis.

The level of labour productivity in the Canadian business sector was about 84% of the U.S. level in 1999. But this aggregate hides considerable differences across the various sectors.

29. The log differences in Table 7 are converted to percentage differences.

The level of labour productivity in the Canadian non-business sector was similar to that in the United States, as it should be since output is basically equal to inputs in the public sector, by construction, and the PPP is calculated here from relative factor costs.

The service sector in Canada had the lowest labour productivity level relative to that in the United States—76% in 1999. The engineering sector, on the other hand, had the highest relative productivity—99% in 1999. The goods sector in Canada was at 81% of U.S. labour productivity in 1999, above the relative level of the service sector but considerably below the engineering sector.

The engineering sector in Canada was much more capital intensive than its U.S. counterpart in 1999. The goods sector in the two countries had similar capital–labour ratios in 1999, while the Canadian service sector was less capital intensive than its U.S. counterpart. When capital intensity is considered and MFP is estimated for the three sub-sectors of the business sector, the sectors move closer to one another because the relative capital intensity of the engineering and goods sectors in Canada is above that of the service sector.

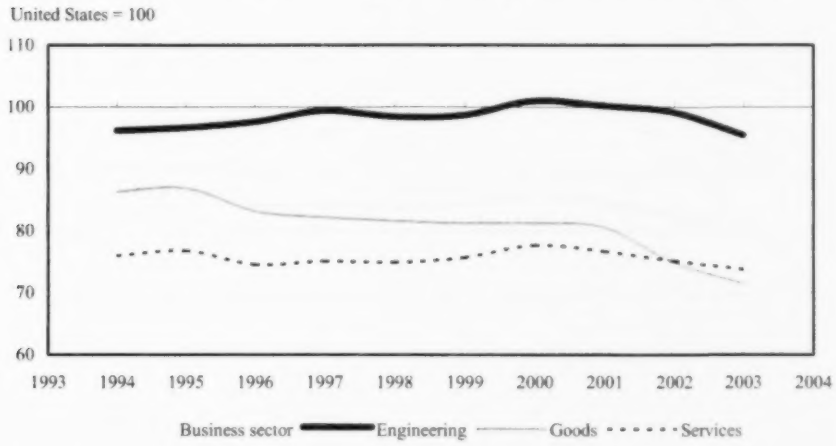
The service and goods sectors in Canada had lower levels of MFP relative to the United States and were behind the United States by about 20% in 1999. The engineering sectors had a higher relative MFP level—behind the United States by only 15% in 1999.

The overall capital–labour ratios are also disaggregated into the M&E capital–labour ratios and the structure capital–labour ratios in Table 8. Canada was behind the United States in M&E capital intensity in all sectors in 1999. The difference was large for the engineering and service sectors but small for the goods sector. M&E capital intensity in the Canadian engineering sector was about 20% behind its U.S. counterpart in 1999. It was 33% behind the U.S. level in the Canadian service sector. The M&E capital intensity in the Canadian goods sector was 5% behind in 1999.

While Canada had lower M&E capital intensity than the United States, it had higher capital intensity in structures in all sectors. The engineering sector in Canada had the highest structure-capital intensity relative to that in the United States, followed by the goods sector and service sector.

Trends in relative Canadian-U.S. levels of productivity and capital intensity—As shown in Figure 3, the level of labour productivity in Canada relative to the United States declined in goods and service sectors over the 1994-to-2003 period. It was virtually unchanged in the engineering sector. The Canadian service sector was considerably behind that in the United States—some 24% in 1994 and it had fallen to 26% by 2003. The relative level of labour productivity in the Canadian goods sector declined sharply from 86% of the United States level in 1994 to 72% in 2003. The engineering sector in Canada started the period in 1994 at 96% of the U.S. level but had increased to 99% of the U.S. level by 1999, and then it declined to 95% of the U.S. level in 2003.

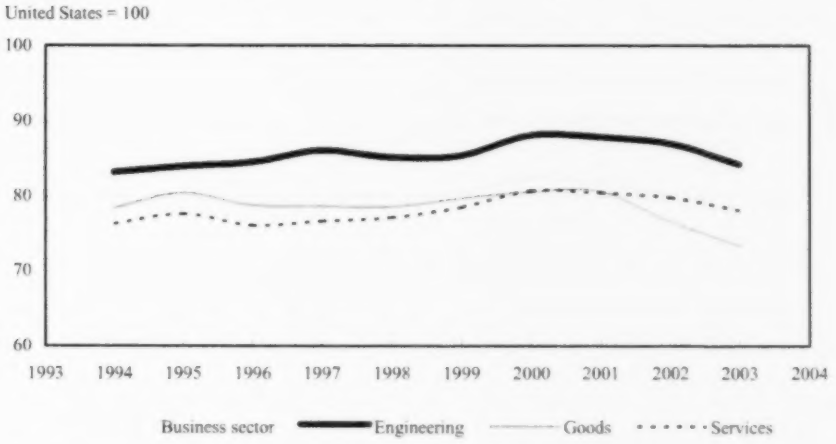
Figure 3
Relative Canadian-U.S. labour productivity in the business sector



Sources: Statistics Canada; and Bureau of Economic Analysis.

Figure 4 shows that the relative Canadian-U.S. MFP levels experienced little change in the service and engineering sectors over the 1994-to-2003 period but declined in the Canadian goods sector. The relative MFP level in the Canadian engineering sector was between 83% and 85% of the U.S. MFP level for the period. The relative MFP level in the Canadian service sector was between 76% and 78% of the U.S. MFP level. The relative MFP level in the Canadian goods sector declined from 78% of the U.S. level to 73% of the U.S. level from 1994 to 2003.

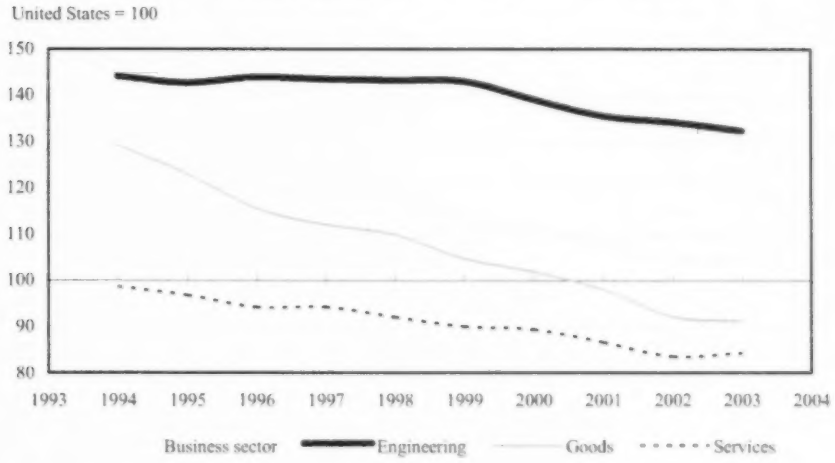
Figure 4
Relative Canadian-U.S. multifactor productivity in the business sector



Sources: Statistics Canada; and Bureau of Economic Analysis.

The capital intensity in Canada, relative to that in the United States, declined in all industries of the business sector for the 1994-to-2004 period (Figure 5). The decline was the largest in the goods sector. The capital intensity in the Canadian goods sector declined from 129% of the U.S. level to 91% of the U.S level over the period.

Figure 5
Relative Canadian-U.S. capital intensity in the business sector



Sources: Statistics Canada; and Bureau of Economic Analysis.

The decline in relative capital intensity in the Canadian business sector occurred for both M&E capital and structure capital. The M&E capital intensity in the Canadian business sector declined from 99% to 77% of the U.S. level for the 1994-to-2003 period. The structure capital intensity declined from 158% to 148% of the U.S. level.

Sources of Canadian-U.S. labour productivity level differences—Table 9 presents the results from decomposing the Canadian-U.S. labour productivity difference into contributions arising from differences in MFP, as opposed to differences in capital intensity. The lower level of labour productivity in Canada relative to the United States was due to the lower level of MFP in all three major industries of the business sector in 1999. The lower M&E capital intensity was also a contributing factor to the lower labour productivity level in the engineering and services sector but not in the goods sector. The higher structure capital intensity in Canada increased the relative level of labour productivity in all three industries of the business sector, and the increase was large in the engineering sector and was small in the goods and service sectors.

Table 9
Sources of Canadian-U.S. labour productivity level difference in major sectors, 1999

	Labour productivity[1]	Machinery and equipment per hour	Structure per hour	Multifactor productivity[2]
	percent	percentage-point contributions		
Business sector	-17.1	-3.5	8.4	-22.0
Engineering sector	-1.3	-4.7	19.2	-15.8
Goods sector	-20.8	-1.5	3.5	-22.7
Service sector	-27.8	-6.4	2.8	-24.2
Non-business sector	6.6	-6.5	7.9	5.2

1. Log difference in labour productivity.
2. Log difference in multifactor productivity.
Note: The Canadian-U.S. productivity difference in the table is calculated as the logarithm of relative Canadian-U.S. productivity levels. A negative number means that Canada has a lower level of productivity that the United States.
Sources: Statistics Canada; and Bureau of Economic Analysis.

3.5 Industry contributions to the Canadian-U.S. productivity difference in the total economy

The Canadian-U.S. productivity difference in the total economy can be decomposed into contributions made by individual industries. The industry contribution to the overall Canadian-U.S. MFP difference can be calculated by multiplying the industry share of nominal GDP—averaged over the two countries—by its MFP difference. Similarly, the industry contribution to the overall Canadian-U.S. labour productivity difference can be calculated by multiplying the industry share of hours worked—averaged over the two countries—by its labour productivity difference.

The measured industry contribution to the overall Canadian-U.S. productivity difference depends on the size and productivity difference of each industry. The shares of nominal output, hours worked and nominal capital stock accounted for by individual industries in Canada and the United States in 1994 and 2003 are presented in Table 10.

The service sector accounted for a smaller share of the total economy in Canada than in the United States in terms of nominal output. The relative importance of the service sector increased after 1994 for both Canada and the United States. For Canada, the service sector's share of output increased from 30% in 1992 to 34% by 2003. For the United States, the service sector's output share increased from 39% to 42% from 1994 to 2003.

The goods and engineering sectors were relatively more important in Canada than in the United States, in terms of their contribution to nominal output. The engineering sector accounted for a much bigger share of nominal output in Canada than in the United States.

The non-business sector in Canada was slightly more important than that in the United States in 1994 in terms of nominal output. The relative importance of the non-business sector declined over time in Canada, while it remained unchanged in the United States. By 2003, the output share of the non-business sector was similar in the two countries.

Table 10
Sector share of output and inputs in Canada and the United States

	1994		2003	
	Canada	United States	Canada	United States
	percent			
Share of nominal gross domestic product				
Engineering sector	21.2	14.8	22.7	15.3
Goods sector	18.3	17.4	17.4	13.5
Service sector	30.3	39.0	33.5	42.2
Non-business sector	30.1	28.9	26.4	28.9
Share of hours worked				
Engineering sector	16.6	12.7	17.1	13.2
Goods sector	18.5	17.3	16.5	13.1
Service sector	41.5	44.8	45.2	46.6
Non-business sector	23.4	25.2	21.2	27.1
Share of nominal machinery and equipment capital				
Engineering sector	33.8	26.1	35.3	25.2
Goods sector	33.7	22.3	27.9	20.0
Service sector	24.0	28.7	29.0	36.3
Non-business sector	8.5	22.9	7.7	18.5
Share of nominal structure capital				
Engineering sector	20.3	9.2	21.2	9.1
Goods sector	4.8	4.1	4.2	3.3
Service sector	21.8	25.8	21.1	22.8
Non-business sector	53.1	60.9	53.5	64.8

Sources: Statistics Canada; and Bureau of Economic Analysis.

The results in Table 11 suggest that the lower level of labour productivity and MFP in the Canadian service sector accounted for most of the labour productivity and MFP differences between Canada and the United States. This is a result of the service sector having the lowest relative levels of labour productivity and MFP in Canada and having the largest share of output and hours worked in the total economy.

Table 11
Industry decomposition of Canadian-U.S. labour and multifactor productivity level differences in the total economy, 1999

	Labour productivity	Multifactor productivity
Log differences in Canadian-U.S. productivity (percent)	-10.7	-13.2
Percentage point contributions of		
Engineering sector	-0.2	-2.8
Goods sector	-3.5	-4.1
Service sector	-12.5	-9.0
Non-business sector	1.5	1.4
Residual	4.0	1.3

Note: The residual contribution includes contribution from the difference in industry mix in Canada and the United States.
Sources: Statistics Canada; and Bureau of Economic Analysis.

3.6 Robustness checks

In the previous sections, we have focused on point estimates of Canadian-U.S. relative labour productivity and MFP. These estimates are derived from constructs that measure output, labour and capital and that are combined analytically in the MFP estimates using weights on both relative capital and labour inputs. Our estimates of each of the variables are subject to error and therefore the point estimates of both relative labour productivity and MFP are subject to a degree of uncertainty. In reality, the true answer must be found in a range of estimates.

To provide the reader with guidance on the nature of this range, this section examines the robustness of the relative Canadian-U.S. MFP levels. We will consider sequentially alternative estimates of PPPs, errors margins in our estimates of the relative levels of capital–labour ratios and possible differences occasioned by the choice of different weights in aggregating investments in M&E and structures.

As we have already emphasized, the PPPs used here are special constructs from relative price data that were not designed for the purpose to which they have been put here. The price data were not devised to provide good coverage at the industry level—they instead focus on final expenditures. They deal with final products, not intermediate inputs that are required for the double deflation of both the outputs and the inputs of industries. The error margins in the PPPs depend on the reliability of relative prices for individual commodities and the list of commodities selected for collecting relative prices (OECD 2002).

One way to assess the accuracy of the PPPs is to chose an alternate set that were estimated from the same final demand relative prices using slightly different assumptions as to which final demand prices to assign to which industries. Rao, Tang and Wang (2004) have also estimated the PPPs for industry output between Canadian and U.S. industries. Their estimate of the PPPs of the business sector was 0.88 for the output in 1999. If this estimate is used, the level of the MFP at the aggregate level in Canada was 91% of the U.S. level in 1999 (Table 12)[30] compared with our estimate of some 88%.

Table 12
Relative Canadian-U.S. multifactor productivity levels in the total economy, alternative estimates

Alternative estimates	1994	1999	2003
		United States = 100	
Point estimate	84.9	87.6	86.9
Purchasing power parities = 0.88	87.9	90.7	89.9
Canadian-U.S. capital–labour ratios + 0.05	83.3	85.9	85.2
Canadian-U.S. capital–labour ratios - 0.05	86.6	89.3	88.5
Rate of return = 0 for structure capital	93.1	96.4	95.2

Sources: Statistics Canada; and Bureau of Economic Analysis.

30. It should be noted that this study did not reconcile the estimates of labour or capital in Canada and the United States as is done here.

Our estimate of relative capital intensity in Canada and the United States may also be subject to error. For example, it is not clear whether both Canada and the United States divide total expenditures on capital between new investment and maintenance in the same way. Should the two countries differ slightly, estimates of relative capital stock may be biased slightly. To examine the robustness of relative MFP levels to errors in capital–labour ratios, we adopt a rule of thumb that allows a 5 percentage point margin surrounding the relative levels of Canadian-U.S. capital–labour ratios. Doing so produces estimates of the relative MFP level in Canada that lie between 86% and 89% of the U.S. level in 1999 (Table12).

Finally, it should be noted that the weights that are used here to aggregate the relative inputs depend on the assumption of a particular form of production technology and that factors are paid their marginal product. To estimate relative MFP levels in Canada and the United States, we have adopted a user-cost approach for estimating capital services and the growth accounting method. The growth accounting method for international comparison assumes that there is perfect competition and constant returns to scale. The user-cost approach for estimating capital services assumes that the rate of return is the same across assets.[31] The assumption of competition in factor markets and constant returns to scale implies that the elasticity of output with respect to capital and labour equals the share of capital and labour in the value of output. The growth accounting method is used both by Statistics Canada and the Bureau of Labour Statistics to estimate MFP and is the most commonly used technique in most other statistical agencies.

Nevertheless, it must be pointed out that there are alternate ways of estimating the weights than those used here. In particular, the weights can be derived from econometric estimates of the marginal product of each input either from the estimation of a production or a cost function. For example, Fuss and Waverman (2005) have adopted an alternative approach for estimating relative MFP levels when examining the source of labour productivity differences in Canada and the United States. Their econometric technique produces an estimate of the rate of return to information and communications technology (ICT) capital that is much higher than the rate of return to other types of capital. To estimate the contribution of ICT capital to Canadian-U.S. labour productivity differences, they assign weights to ICT and M&E capital that are much higher than their shares of output as used in the growth accounting method adopted here. The evidence based on their approach shows that the relative MFP difference between Canada and the United States was small. The MFP level in Canada was 95% of the U.S. level in 2003 in the business sector.[32] More than 70% of Canadian-U.S. labour productivity differences were accounted for by Canada's lower capital–labour ratio in 2003. Reducing the weights on structures and increasing them on M&E will increase the estimates of relative MFP between Canada and the United States because Canada has relatively less M&E, as we have shown earlier, and relatively more structures. Increasing the weight on the former and decreasing it on

31. The other main difference between the two papers relates to the use of 'effective' capital stock in Fuss and Waverman (2005). Fuss and Waverman (2005) constructed effective capital stock that is a function of information and communications technology capital stock and the stock's characteristics—such as the penetration rate of telephone, personal computers, and the degree of digitalization of the country's telecommunication infrastructure.

32. Multifactor productivity was called unexplained residual factor in their paper.

the latter will reduce the Canadian-U.S. capital–labour ratios and therefore give more weight to capital deficiencies in explaining relative labour productivity differences in Equation (2).

Others also have challenged the standard growth accounting framework. For example, Romer (1987) estimated a growth regression using the data for the 115 countries in the Penn World Table and reports that the elasticity of output with respect to capital was much higher than the share of capital in the value of output that is implied by Solow's growth accounting method.[33]

In contrast, Mankiw, Romer and Weil (1992) and Islam (1995) have provided corroborative evidence for the cost share technique associated with the growth accounting method in international comparisons. Those studies either allow for the role of human capital investment or use panel data econometrics. Those studies also find that the elasticity of output with respect to capital was similar to the share of capital in the value of output.

Even if we adopt the convention that the cost shares for capital are the correct metric for weighting capital, it may be that each capital asset earns different rates of return. The studies referred to above make no distinction between different types of capital stock. When we distinguish between types of capital for growth accounting and calculate capital services using the user-cost approach, this paper makes an additional assumption that the rate of return is the same across different types of capital assets. But De Long and Summers (1991) found that the rate of return to M&E was 30% in well-functioning market economies.[34] Fuss and Waverman (2005) argue that the rate of return to ICT capital is much higher than the rate of return to other capital.

To examine the effect of possible differences in the rates of return to M&E and structure capital, we have re-estimated the relative MFP levels in Canada and the United States with an extreme assumption that the rate of return to structure capital is zero. The rate of return to M&E capital is determined endogenously, using the equation that assumes the sum of capital costs across assets equals capital income. This leads to an increase in the share of M&E capital in the value of output from 15% to 35% and a decline in the share of structure capital from 25% to 5% for estimating aggregate MFP levels in Canada and the United States in 1999. When this is done, the estimated aggregate MFP levels were similar in Canada and the United States (Table 12), much as it is in Fuss and Waverman (2005). Not surprisingly, this technique suggests that the Canadian-U.S. labour productivity differences were due to lower M&E investment in Canada. But it should be noted that it is rather unlikely that the return to structures was zero and that this estimate therefore probably provides an upper limit to the level of relative Canadian-U.S. MFP.

33. Sargent and James (1997) found that the elasticity of output with respect to capital was close to one in Canada, which was much larger than its share of output.

34. We have estimated a growth equation using pooled Capital, Labour, Energy, Materials and Services data for Canada and the United States. The evidence is consistent with the findings in De Long and Summers (1991). Machinery and equipment is associated with output growth, and structure investment is not. But we treat this finding with caution because it is at odds with evidence from case studies.

4 Conclusions

Comparisons of productivity levels between Canada and the United States need careful synchronization of databases and methodologies. Our first attempt to do this examined the relative level of labour productivity in Canada compared with the United States. That paper focused on developing comparable estimates of labour inputs and it found that Canada was behind the United States by around 7 percentage points in 1999, once corrections were made for differences in sources and methodologies in the two countries.

This paper examines whether multifactor productivity (MFP) differences also exist between the two countries. Labour productivity differences may be the result of differences in overall efficiency, as measured by MFP, or the result of deficiencies in capital.

In order to measure whether MFP is higher or lower in Canada, estimates of capital inputs are developed that make use of comparable sources and methodology. Assets are broken down into three classes—machinery and equipment, buildings and engineering structures.

Capital intensity is measured by capital per hour. Taken together, capital intensity in all three classes is as high in Canada as it is in the United States. Therefore, the relative productivity level in Canada is about the same as in the United States—whether measured as labour productivity or MFP.

But there are considerable differences in Canada's capital intensity across asset classes. Canada has considerably less machinery and equipment (M&E), about the same amount of buildings and considerably more engineering construction—dams, pipelines, railway lines, telecommunications equipment and oil exploration.

Part of the reason for these differences is that Canada has a much larger group of industries where engineering construction is important; and comparison of one economy to another at the aggregate level may conceal differences across sectors. Therefore, MFP and labour productivity levels were developed for the goods sector, for services and for the group of industries where engineering construction is important—what is referred to here as the engineering sector.

The sector results show that the level of both labour and multifactor productivity in the goods and the engineering sectors are much closer to the level of the United States. In 1999, the level of labour productivity of the engineering sector was 98% that of the United States. It was 81% for the goods sector. In contrast, it was only 76% for the service sector. The service sector accounted for most of the labour productivity difference between Canada and the United States.

When capital intensity is considered and MFP is estimated for the three sectors, the sectors move closer to one another because the capital–labour intensity of the engineering and goods sector in Canada is above that of the service sector. Nevertheless, the service sector still accounts for the majority of the overall productivity gap with the United States.

Over the 1994-to-2003 period, the overall gap with the United States widened for labour productivity. The decline was accounted for by the decline in the goods and service sectors. The

level of labour productivity in the Canadian goods sector declined from 86% of the U.S. level to 72% of the U.S. level from 1994 to 2003. The level of labour productivity in the Canadian service sector declined from 76% of the U.S. level to 74% over the period.

During this same period of time, the relative capital intensity of the goods sector fell considerably relative to its U.S. counterpart—with regards to both M&E and structures.

The level of MFP in Canada relative to that in the United States increased in the 1994-to-1999 period and declined after 1999. It increased from 78% of the U.S. level in 1994 to 80% in 1999, and then declined to 78% in 2003. The decline of the relative MFP level in Canada after 2000 was mainly due to the decline in the goods sector. The relative MFP level in the Canadian engineering sector showed a slight decline after 2000, while it was unchanged in the service sector.

This paper has also stressed that the point estimates of relative productivity that are constructed here are subject to a margin of error. The price deflators and the estimates of capital stock are subject to measurement error. Reasonably small errors in each area would mean that the estimates derived herein cannot rule out the possibility that there are really no differences in the productivity levels of the goods and engineering sectors in Canada from their U.S. counterparts. Our conclusion that the overall gap is caused mainly by the service sector would, however, remain.

More important is another caveat that arises not from imprecision on the measurement of labour or capital or relative prices, but from the choice of the weights that are used to aggregate the different types of capital assets. The asymmetrical nature of relative capital intensity by asset type—lower in Canada for M&E but higher in Canada for structures and engineering construction—means that the estimates of MFP levels are particularly sensitive to the weights that are used to aggregate the various assets. Should the weights on M&E be increased and those on structures be decreased, the differences in the levels of MFP would decline; in the case of engineering construction and the goods sector, they would disappear completely. Expressed somewhat differently, almost all of the differences in the labour productivity levels would be explained not by lower levels of overall efficiency but by lower levels of capital intensity.

This change in the conclusions is significant. If overall efficiency is not purely related to capital intensity, solutions to the productivity gap will differ if it is due to overall efficiency as opposed to a deficiency in capital.

What then are the areas where additional work needs to be done in order to produce more precise estimates of the productivity gap? First, as emphasized in our previous paper (Baldwin et al. 2005), the relative price deflators need to be improved. They need to move away from focusing just on expenditures in order to provide deflators for the comparison of outputs at the industry level. They need to focus on industry outputs and inputs to enable value added to be deflated. They need to take into account both production destined for domestic consumption and export markets. They also need to be improved for investment goods—not just M&E but also for structures and engineering. Second, more work needs to be devoted to examining the aggregation weights that are used to combine the different assets (M&E versus structures). Third, the comparability of the meaning of investment in each country needs to be examined.

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